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*Indian Standard*

SATURATED VAPOUR PRESSURE  
AND TEST PRESSURE FOR LOW PRESSURE  
LIQUEFIABLE GASES CONTAINED IN  
GAS CYLINDERS

( First Reprint MARCH 1983 )

UDC 661.91-404.984 : 533.21 : 621.642.02



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INDIAN STANDARDS INSTITUTION  
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG  
NEW DELHI 110002

# Indian Standard

## SATURATED VAPOUR PRESSURE AND TEST PRESSURE FOR LOW PRESSURE LIQUEFIABLE GASES CONTAINED IN GAS CYLINDERS

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# *Indian Standard*

## SATURATED VAPOUR PRESSURE AND TEST PRESSURE FOR LOW PRESSURE LIQUEFIABLE GASES CONTAINED IN GAS CYLINDERS

### 0. FOREWORD

**0.1** This Indian Standard was adopted by the Indian Standards Institution on 27 April 1978, after the draft finalized by the Gas Cylinders Sectional Committee had been approved by the Mechanical Engineering Division Council.

**0.2** Manufacture, possession and use of any gas when contained in cylinders, in compressed or liquefied state is regulated under the Gas Cylinder Rules, 1940, of the Government of India as amended from time to time. This standard has been prepared in consultation and agreement with the statutory authorities under those rules.

**0.3** This standard has been prepared for the guidance of the designers, users, manufacturers and fillers of gas cylinders for low pressure liquefiable gases to ensure their safe design, handling and use.

**0.4** Indian Standards Institution has already published the following specifications for gas cylinders for low pressure liquefiable gases:

IS : 3196-1974 Welded low carbon steel gas cylinder exceeding 5-litre water capacity for low pressure liquefiable gases (*second revision*)

IS : 7142-1974 Welded low carbon steel gas cylinders for low pressure liquefiable gases, not exceeding 5-litre water capacity

IS : 7680-1975 Welded low carbon steel gas cylinders for ammonia (*anhydrous*) gas

IS : 7681-1975 Welded low carbon steel gas cylinders for chlorine gas

IS : 7682-1975 Welded low carbon steel gas cylinders for methyl bromide gas

**0.5** The maximum internal pressure,  $p_d$  which a low pressure liquefiable gas when contained in a cylinder can develop, is its saturated vapour pressure at the maximum attainable temperature, which is taken as 65°C in India. In the case of low pressure liquefiable gases, the saturated vapour pressure is independent of the filling ratio ( *see IS : 3710-1978\** ).

However, in the design of cylinders a safety factor of 1.5 is used. Therefore, the pressure to be used in the formulae for calculating the wall thickness of the gas cylinder ( which is same as the hydrostatic test pressure ) of cylinders containing low pressure liquefiable gas theoretically equals 1.5 times the saturated vapour pressure of the gas at 65°C.

**0.6** The values of saturated vapour pressure ( which equals the maximum developed pressure ) at 65°C,  $p_d$ , and the minimum theoretical test pressure,  $p_{th}$ , given in this standard hold good only for pure gases. The presence of any impurity will give rise to higher pressures and, therefore, such cylinders should be designed to withstand higher pressures.

**0.7** The recommended test pressures,  $p_h$ , given in this standard are not less than 1.5 times the saturated vapour pressure of the gas at 65°C,  $p_d$ , subject to a minimum of 18 kgf/cm<sup>2</sup>. However, in the interests of industrial standardization, to account for the impurities present and to facilitate the change of cylinders from one gas service to another, the values of minimum recommended test pressures,  $p_h$  have been rationalized. Thus for 50 different gases the number of test pressure values has been rationalized to about 10 only. In the interest of safety, particularly due to the poisonous nature of certain gases, still higher test pressure has been recommended in the case of such gases. In all cases, however, cylinders should be tested at the pressure marked on the cylinder.

**0.8** Presently there are a number of cylinders in circulation which have earlier been permitted by the statutory authority to be tested at a test pressure which is different from that recommended in this standard. At the time of periodical inspection, all such cylinders should be tested at the test pressure marked on the cylinder.

**0.9** This standard is based on BS 5355 : 1976 ' Filling ratios and developed pressures for liquefiable and permanent gases ' issued by the British Standards Institution. Data from some other sources has also been taken in a few cases.

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\*Filling ratios for low pressure liquefiable gases contained in cylinders (*first revision* ).

**0.10** The quantities in this standard have been expressed in technical metric units. However, in view of the introduction of International System (SI) units in the country, the relevant SI units and the corresponding conversion factors are given below for guidance:

$$\begin{aligned}
 1 \text{ kgf/cm}^2 &= 98.0665 \text{ kPa ( kilopascal )} \\
 &= 0.0980665 \text{ MPa ( megapascal )} \\
 &= 0.980665 \text{ bar}
 \end{aligned}$$

**0.11** For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960\*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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## 1. SCOPE

**1.1** This standard specifies the values of the saturated vapour pressure at 65°C, and the recommended test pressures for low pressure liquefiable gases contained in gas cylinders.

## 2. TERMINOLOGY

**2.1** For the purpose of this standard, the following definitions in addition to those given in IS : 7241-1974† shall apply.

**2.1.1** *Low Pressure Liquefiable Gas* — A liquefiable gas having a critical temperature above 70°C.

**2.1.2** *Hydrostatic Test Pressure,  $p_h$*  — Pressure to which a cylinder is subjected to in the hydrostatic pressure test.

**2.1.3** *Design Pressure* — Pressure used in the design calculations of a cylinder for the purpose of determining its minimum wall thickness.

**NOTE** — Design pressure is taken as equal to the hydrostatic test pressure.

**2.1.4** *Maximum Developed Pressure,  $p_d$*  — The internal pressure developed by the gas at the maximum attainable temperature of 65°C. In the case of low pressure liquefiable gases, it equals the saturated vapour pressure of the gas at the temperature of 65°C.

## 3. SATURATED VAPOUR PRESSURE AND TEST PRESSURE

**3.1** The values of the saturated vapour pressure at 65°C,  $p_d$ , theoretical minimum test pressure,  $p_{ht}$ , and the recommended test pressure,  $p_h$  for low pressure liquefiable gases are given in Table 1.

\*Rules for rounding off numerical values ( revised ).

†Glossary of terms used in gas cylinders technology.

**TABLE 1 SATURATED VAPOUR PRESSURE AND TEST PRESSURE**  
 ( Clause 3.1 )

NAME OF GAS	CHEMICAL SYMBOL	SATURATED VAPOUR PRESSURE, $\rho_d$ AT 65°C, kgf/cm <sup>2</sup> ( GAUGE )	THEORETICAL Min TEST PRESSURE, $\rho_{th} = (1.5 \rho_d)$ , kgf/cm <sup>2</sup> ( GAUGE )	RECOMMENDED TEST PRESSURE, $\rho_h$ kgf/cm <sup>2</sup> ( GAUGE )	CRITICAL TEMPERATURE
(1)	(2)	(3)	(4)	(5)	(6)
Ammonia	NH <sub>3</sub>	29.04	43.56	45	+132.4°C
Boron trichloride	BCl <sub>3</sub>	4.06	6.09	60†	+178.8°C
Butadiene ( vinylethylene, divinyl )	C <sub>4</sub> H <sub>6</sub>	7.36	11.04	18	+152°C
Butane ( normal )	C <sub>4</sub> H <sub>10</sub>	6.32	9.48	18	+152°C
Butene	C <sub>4</sub> H <sub>8</sub>	—	—	18	+146.4°C
Chlorine	Cl <sub>2</sub>	19.90	29.85	30	+144°C
Chlorine trifluoride	ClF <sub>3</sub>	6.26	9.39	18	+153°C
Cyanogen	(CN) <sub>2</sub>	16.17	24.26	100†	+128°C
Cyanogen chloride	ClCN	4.71	7.06	100†	+174°C
Cyclopropane	C <sub>3</sub> H <sub>6</sub>	19.06	28.59	30	+124.4°C
Dichlorodifluoromethane ( R-12* )	CCl <sub>2</sub> F <sub>2</sub>	16.29	24.44	25	+112°C
Dichloromonofluoromethane ( R-21* )	CHCl <sub>2</sub> F	5.04	7.56	18	+178.5°C
1.2 Dichlorotetrafluoroethane ( R-114* )	CClF <sub>2</sub> CClF <sub>2</sub>	5.60	8.40	18	+145.7°C
1.1 Difluoroethane ( ethyldene fluoride ) ( R-152a* )	CH <sub>3</sub> CHF <sub>2</sub>	16.17	24.26	25	+113.5°C
Dimethylamine	(CH <sub>3</sub> ) <sub>2</sub> NH	6.13	9.20	18	+164.6°C
Dimethylether ( methyl ether, methyl oxide )	(CH <sub>3</sub> ) <sub>2</sub> O	15.47	23.20	25	+126.9°C

Ethylamine ( aminoethane )	$\text{C}_2\text{H}_5\text{NH}_3$	4.06	6.09	18	+183°C
Ethyl chloride ( chloroethane )	$\text{C}_2\text{H}_5\text{Cl}$	4.45	6.68	18	+187.2°C
Ethylene oxide	$\text{C}_2\text{H}_4\text{O}$	4.92	7.38	18	+195.8°C
Hydrogen cyanide ( anhydrous )	HCN	2.81	4.22	100†	+183.5°C
Hydrogen fluoride ( anhydrous )	HF	3.32	4.98	18	+188°C
Hydrogen sulphide	$\text{H}_2\text{S}$	48.07	72.10	75	+100.4°C
Isobutane ( 2-methyl propane ) ( R-600a* )	$\text{CH}(\text{CH}_3)_3$	8.82	13.23	18	+135°C
Isobutylene	$\text{CH}_3=\text{C}(\text{CH}_3)_2$	7.74	11.61	18	+144.73°C
LPG‡ ( liquefied petroleum gas )	—	16.87	25.30	25	—
Methylmercaptan ( methanethiol )	$\text{CH}_3\text{SH}$	—	—	18	+196.8°C
Methylamine ( aminomethane )	$\text{CH}_3\text{NH}_2$	11.03	16.54	18	+156.9°C
Methyl bromide	$\text{CH}_3\text{Br}$	5.70	8.55	18	+191°C
Methyl chloride	$\text{CH}_3\text{Cl}$	14.92	22.98	25	+143.1°C
Monochlorodifluoroethane ( R-142b* )	$\text{CH}_2\text{CClF}_2$	9.15	13.71	18	+137°C
Monochlorodifluoromethane ( R-22* )	$\text{CHClF}_2$	26.71	40.06	45	+96°C
Monochloromonobromodi- fluoromethane ( R-12B <sub>1</sub> )	$\text{CClF}_2\text{Br}$	7.07	10.60	18	+153.8°C

\*This is the refrigerant number of the gas in accordance with ISO/R 817 - 1974 'Organic refrigerants — Number designation' issued by the International Organization for Standardization.

†Due to the high toxicity of the gas, the value of recommended test pressure,  $p_{th}$ , is considerably higher than that of theoretical test pressure,  $p_{th}$ .

‡The value of saturated vapour pressure for LPG varies depending upon the proportion of constituent gases. The value given here should not, therefore, be taken as absolute value.

( Continued )

TABLE 1 SATURATED VAPOUR PRESSURE AND TEST PRESSURE — *Contd*

NAME OF GAS	CHEMICAL SYMBOL	SATURATED VAPOUR PRESSURE, $p_d$ AT 65°C, kgf/cm <sup>2</sup> (GAUGE)	THEORETICAL Min TEST PRESSURE, $p_{ht} = (1.5 p_d)$ , kgf/cm <sup>2</sup> (GAUGE)	RECOMMENDED TEST PRESSURE, $p_h$ kgf/cm <sup>2</sup> (GAUGE)	CRITICAL TEMPERATURE
(1)	(2)	(3)	(4)	(5)	(6)
Monochloropentafluoroethane (R-115*)	CCl <sub>2</sub> CF <sub>3</sub>	22.48	33.78	35	+79.9°C
Monochlorotetrafluoroethane (R-124a*)	CHF <sub>2</sub> CClF <sub>3</sub>	5.98	8.97	18	—
Monochlorotrifluoroethane (R-133a*)	CH <sub>2</sub> ClCF <sub>3</sub>	5.81	8.72	18	+144.2°C
Monochlorotrifluoroethylene (R-1113*)	CClF=CF <sub>2</sub>	16.53	24.80	25	+107°C
8 Nitrogen tetroxide (nitrogen peroxide)	N <sub>2</sub> O <sub>4</sub>	5.25	7.88	60†	+158°C
Nitrosyl chloride	NOCl	10.79	16.18	50†	+173°C
Octafluorocyclobutane (R-C318*)	C <sub>4</sub> F <sub>8</sub>	8.74	13.11	18	+114.2°C
Phosgene (carbonyl chloride)	COCl <sub>2</sub>	5.18	7.77	60†	+182°C
Propane	C <sub>3</sub> H <sub>8</sub>	22.66	33.99	35	+96.8°C
Propene	C <sub>3</sub> H <sub>6</sub>	27.29	40.94	45	+91.8°C
Refrigerant gas mixture R 500* (R 12*, 73.8% + R 152a*, 26.2%, by mass)	—	19.58	29.37	30	+105°C
Refrigerant gas mixture R 502* (R 22*, 48.8% + R 115*, 51.2%, by mass)	—	28.01	42.01	45	+90.1°C

Refrigerant mixture ( R 12* 88%+ ethylene oxide 12%, by mass )	—	13.38	20.07	25	—
Sulphur dioxide	SO <sub>2</sub>	11.95	17.92	18	+157.5°C
Trichloromonofluoromethane ( R-11* )	CCl <sub>2</sub> F	2.63	3.94	18	+198°C
Trimethylamine	(CH <sub>3</sub> ) <sub>3</sub> N	5.70	8.55	18	+160.2°C
Vinyl bromide	CH <sub>3</sub> =CHBr	—	—	18	+200°C
Vinyl chloride	CH <sub>3</sub> =CHCl	10.60	15.90	18	+156.5°C
Vinylmethyl ether	CH <sub>3</sub> OCH=CH <sub>2</sub>	5.62	8.43	18	—

\*This is the refrigerant number of the gas in accordance with ISO/R 817-1974 'Organic refrigerants — Number designation' issued by the International Organization for Standardization.

†Due to the high toxicity of the gas, the value of recommended test pressure;  $p_h$ , is considerably higher than that of theoretical test pressure,  $p_{ht}$ .

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